CLAIMS

What is claimed is:

Sub A1 1. A method for raising a spacecraft launched into a transfer orbit about the Earth from the transfer orbit to a geosynchronous orbit, comprising the steps of:

launching a spacecraft having chemical and electric propulsion thrusters and a solar array;

firing the chemical propulsion thrusters at apogees of intermediate orbits, starting from the transfer orbit initiated by the launch vehicle, to successively raise perigees of the orbit until the perigee clears the Van Allen radiation belts;

firing the electric propulsion thrusters to raise the orbit of the spacecraft from the orbit achieved by the chemical propulsion thrusters firing step to near geosynchronous orbit while steering the thrust vector and solar array to maintain the sun's illumination on the solar array; and

selectively firing the chemical and/or electric propulsion thrusters to achieve final geosynchronous orbit.

2. The method recited in Claim 1 wherein the thrust vector is substantially normal to the axis of the solar array and the sun is maintained substantially normal to the solar array.

Sub A2 3. The method recited in Claim 1 wherein the thrust vector is not normal to the axis of the solar array and the thrust vector is steered to provide sufficient solar array power to perform maneuvers and minimize propellant usage and/or time to achieve final orbit.

4. The method recited in Claim 1 wherein the transfer orbit is a subsynchronous orbit.

5. The method recited in Claim 1 wherein the transfer orbit is a supersynchronous orbit.

6. The method recited in Claim 1 wherein a thruster firing profile for firing the thrusters is generated onboard the spacecraft.

7. The method recited in Claim 1 wherein a thruster firing profile for firing the thrusters is generated on the Earth 13 and uplinked to the spacecraft.

8. The method recited in Claim 1 wherein a spacecraft steering profile is generated on the Earth that steers the thrust vector (ΔV) to maintain the illumination of the sun's rays substantially normal to solar array.

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~~9. The method recited in Claim 1 wherein a spacecraft steering profile is generated on the Earth that steers the thrust vector (ΔV) such that the thrust vector is not normal to the axis of the solar array and the thrust vector is steered to provide sufficient solar array power to perform maneuvers and minimize propellant usage and/or time to achieve final orbit.~~

10. The method recited in Claim 1 wherein a spacecraft steering profile is generated onboard the spacecraft that steers the thrust vector (ΔV) to maintain the illumination of the sun's rays substantially normal to solar array.

11. The method recited in Claim 1 wherein the step of firing the electric propulsion thrusters to raise the orbit of the spacecraft is periodically revised to compensate for disturbances experienced by the spacecraft.

12. The method recited in Claim 1 wherein the step of firing the electric propulsion thrusters to raise the orbit of the spacecraft is completed prior to reaching a desired on-orbit location whereupon chemical propulsion thruster firings are used to guide the spacecraft to the final desired orbit position to compensate for disturbances experienced by the spacecraft.

13. The method recited in Claim 1 wherein the step of firing the electric propulsion thrusters to raise the orbit of the spacecraft is completed upon reaching a desired on-orbit location and chemical propulsion thruster firings are interspersed with electric thruster operation to guide the spacecraft to the final desired orbit position to compensate for disturbances experienced by the spacecraft.

14. The method recited in Claim 1 wherein the step of firing the electric propulsion thrusters to raise the orbit of the spacecraft includes operating the electric thrusters in a throttled-back mode to enable increased acceleration capability to cope with disturbances experienced by the spacecraft.

15. The method recited in Claim 1 wherein the step of firing the electric propulsion thrusters to raise the orbit of the spacecraft comprises initially turning off one or more of a plurality of electric thrusters turned off so they can be turned on at a later time to give increased acceleration capability in the presence of disturbances experienced by the spacecraft.

16. The method recited in Claim 1 wherein the step of firing the electric propulsion thrusters to raise the orbit of the spacecraft comprises pre-planned electric thruster coast periods that are selectively shortened or lengthened in duration to compensate for disturbances experienced by the spacecraft.

17. The method recited in Claim 1 wherein the step of firing the electric propulsion thrusters to raise the orbit of the spacecraft comprises adjusting attitude steering profiles using a plurality of momentum wheels.

18. The method recited in Claim 1 wherein the step of firing the electric propulsion thrusters to raise the orbit of the spacecraft comprises pointing the resultant thrust vector away from the center of mass of the spacecraft.

19. The method recited in Claim 18 wherein gimbals are used to point the thrusters away from the center of mass of the spacecraft to provide control torque.

20. The method recited in Claim 18 wherein one or more thrusters are differentially throttled to point the resultant thrust away from the center of mass of the spacecraft to provide control torque.

21. The method recited in Claim 18 wherein one thruster on either the North or South side of the spacecraft is used to increase the effective thrust and decrease the duration of the electric orbit raising phase to raise the spacecraft from the orbit achieved by the chemical propulsion thrusters firing step to near geosynchronous orbit.

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22. The method recited in Claim 18 wherein two adjacent thrusters on either the North or South side of the spacecraft are used to increase the effective thrust and decrease the duration of the electric orbit raising phase to raise the spacecraft from the orbit achieved by the chemical propulsion thrusters firing step to near geosynchronous orbit.

23. A system for raising a spacecraft launched into a transfer orbit about the Earth from the transfer orbit to a geosynchronous orbit, comprising:

a spacecraft comprising chemical and electric propulsion thrusters and a solar array;

a processor onboard the spacecraft for:

firing the chemical propulsion thrusters at apogees of intermediate orbits, starting from the transfer orbit initiated by the launch vehicle, to successively raise perigees of the orbit until the perigee clears the Van Allen radiation belts;

firing the electric propulsion thrusters to raise the orbit of the spacecraft from the orbit achieved by the chemical propulsion thrusters firing step to near geosynchronous orbit while steering the thrust vector and solar array to maintain the sun's illumination on the solar array; and

selectively firing the chemical and/or electric propulsion thrusters to achieve final geosynchronous orbit.

24. The system recited in Claim 23 wherein the spacecraft comprises a processor that generates a thruster firing profile for firing the thrusters that is generated onboard the spacecraft.

25. The system recited in Claim 24 wherein the processor generates a spacecraft steering profile onboard the spacecraft that steers a thrust vector (ΔV) to maintain the illumination of the sun's rays substantially normal to solar arrays of the spacecraft.

Sub A5 26. The system recited in Claim 24 wherein the processor generates a spacecraft steering profile onboard the spacecraft that steers a thrust vector (ΔV) such that the thrust vector is not normal to the axis of the solar array and the thrust vector is steered to provide sufficient solar array power to perform maneuvers and minimize propellant usage and/or time to achieve final orbit.

27. The system recited in Claim 23 further comprising:

ground apparatus including a processor that determines a thruster firing profile for firing the thrusters and generates thruster firing commands that implement the thruster firing profile, and communication apparatus that uplinks commands to the spacecraft.

28. The system recited in Claim 27 wherein the processor in the ground apparatus determines a spacecraft steering profile for steering the thrust vector to maintain the illumination of the sun's rays substantially normal to solar array and generates spacecraft steering commands that implement the spacecraft steering profile, and wherein the communication apparatus uplinks spacecraft steering commands to the spacecraft.

Sub A6

29. The system recited in Claim 27 wherein the processor in the ground apparatus determines a spacecraft steering profile for steering the thrust vector produced by the thrusters such that the thrust vector is not normal to the axis of the solar array and generates spacecraft steering commands that implement the spacecraft steering profile wherein the thrust vector is steered to provide sufficient solar array power to perform maneuvers and minimize propellant usage and/or time to achieve final orbit, and wherein the communication apparatus uplinks spacecraft steering commands to the spacecraft.